Day Two
Report Out of Science Goal Proposals

Langdon Morris

Make a pitch for your proposal because we're going to vote for our favorite projects.

Team 2 – Ocean and Land Surface

Here's our first proposal. Gas fluxes response and feedback. Below this line is response and adaptive management. The last is a shorter time scale. It's reactive response. We can use UAVs to solve measurement problems in real-time, such as fire, volcano, etc. We followed a format that incorporated our priorities and where the value add is for others.

Early warning to us meant advance warning of climate change. Negotiation information is being able to quantify these kinds of changes in the earth, such ice sheet thickness and gases. We want to deliver this information so that decision-making and lawmakers can make better choices.

We have gases listed as an early warning because you sometimes get additional methane from arctic areas and you would want to know that. There are large deposits of methane ice and when that melts you get a real greenhouse problem.

Here is our list where we describe why UAVs are required.
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We listed repetitive transects because of the endurance and boredom factor in manned missions.

How we can use this information in our lifetimes is for agriculture, fisheries, coral reef. We can sell this to the public because it is about economy and ecosystem stability.

Ocean and Land Surface

2 Ocean and Land Sur-

M4b+2W304

SCIENCE GOAL	BENEFIT TO SOCIETY
	Models and Predictions *CCSP Priorities
1.) Gas fluxes Response and feedback	Early warning Negotiation Info
2.) Cryosphere response and feedback	Early warning Negotiation Info Awareness
Response and adaptive management	
3) Biosphere response Agriculture Fisheries Coral reefs	Economy Ecosystem Stability Sustainability
4) Hazard & EVENTS	Short term prediction Emergency asst Logistical Support

-rface.

2

M4+2W404

OBSERVATIONS	WHY UAV?
Trace gas fluxes of: - CO_2 - H_2O - Methane - Bromane - Sulphur - sulphur compounds	Vertical Resolution Remote Low level in situ data High spatial Res. ≈ 1 Meter scale Can operate in all conditions
Polar. Ice sheet thickness Accumulation rate surface elevation Sea ice and snow thickness	Remote access Repetitive High spatial and temporal resolution Specialized instruments that can not be operated on piloted aircraft or satellites.
Visual IR multi-spectral Hyper spectral Lidar	Remote locations Proximity for detail Calibration/ground truthing Repetitive measurements - Pilot burnout Targeted to special events Real time data needs
Thermal imaging Surface deformation Soil Moisture fuel biomass & moisture Aerosol and gas	Rapid response Danger measurements, Real time data transmission High temporal and spacial resolution

Team 4 – Atmospheric Observations

We reworded our goals from yesterday. Our first goal is to determine and understand carbonaceous and other aerosols in global warming. Here are the benefits we see, such as health impacts on human populations, improved treatments.

In terms of observational needs, we see the need for vertical profiles and longer duration missions. We need high spatial and temporal observations. We need to determine the emissions sources. We need to determine the microphysical properties of clouds. There would need to be a large scale meteorological perspective.

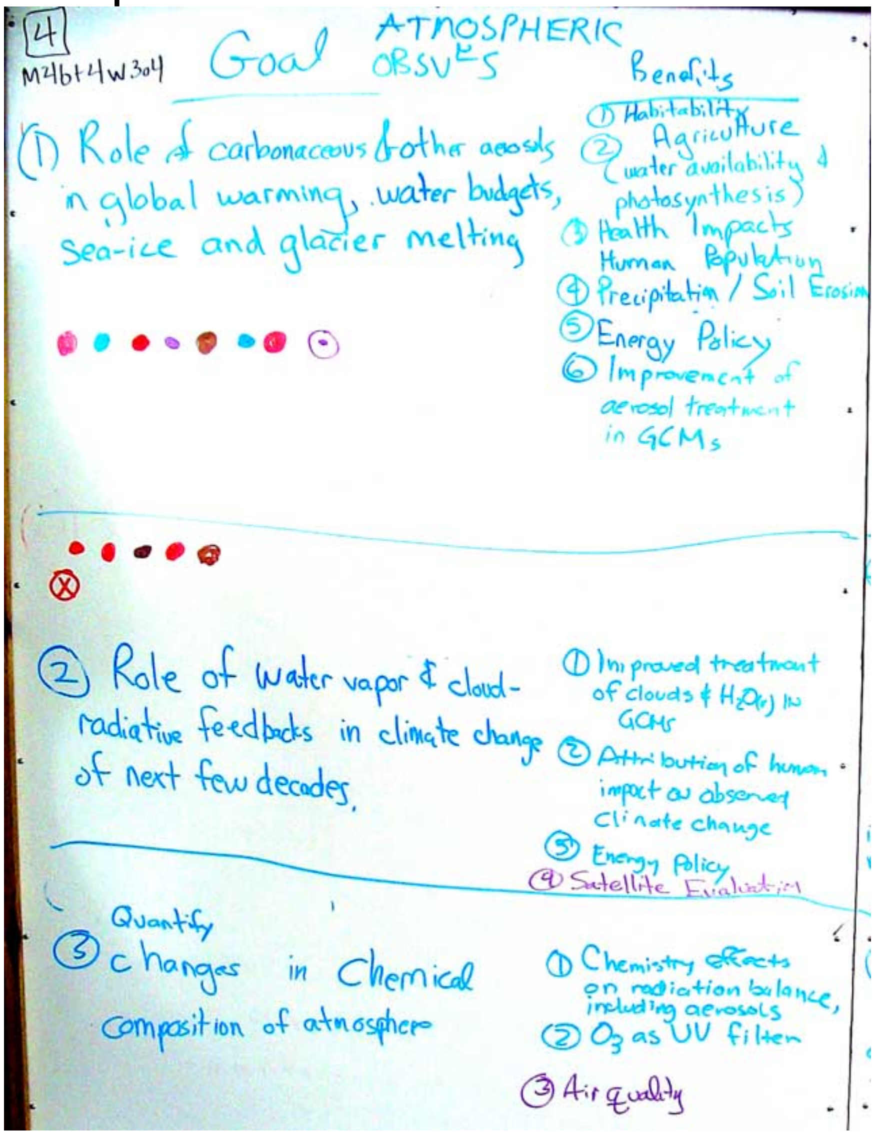
We would need routine observations.

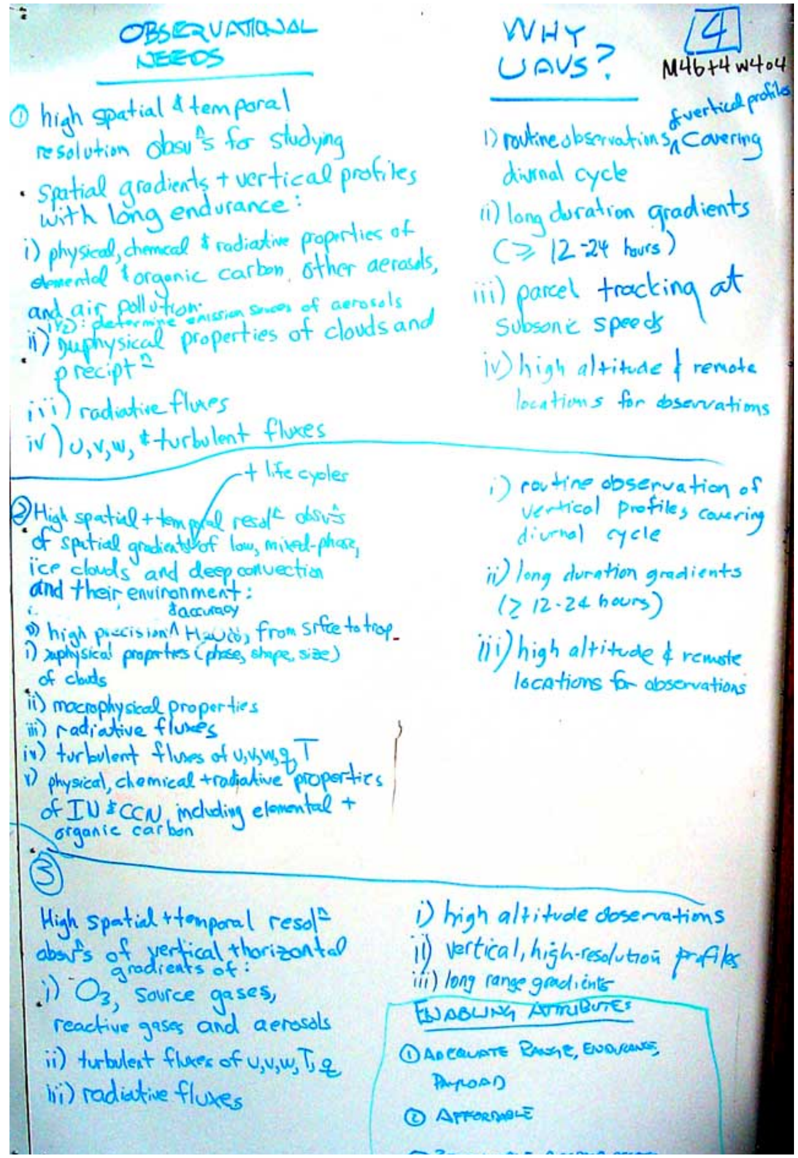
In the second goal, we need to look at the role of water vapor and cloud-radiative feedbacks.

The observation needs are very similar to our first goal. We also need the microphysical properties of supercooled water, turbulent fluxes and the chemical properties of ice nuclei and dust which may be acting as ice nuclei.

Our third goal is to quantify changes in the chemical composition of the atmosphere. The benefits include air quality and ozone as a UV filter. We need high spatial and temporal resolution, as well as adequate range and payload capacity.

Atmospheric Observations





Team 1 – Climate

Our first goal is to understand the sensitivity of climate to forcings. Let me read the board here.

Our next science goal is to determine sources and sinks of carbon. Here are our benefits and observation requirements. The suborbital component gets into the high sensitivity in situ measurements.

Question: What do you mean by carbon?

We mean the entire carbon cycle. We were referring to CO2 and methane.

Let's stick with these words because other things could be meant by just the word carbon, because you're not including organic or black carbon.

It is primarily ocean and land sinks. The requirements are the low and slow that we talked about yesterday.

There are conditions that you don't want to risk a pilot to understand the fluxes. So if you wait for safety to fly, you will have skewed data.

We acknowledged we were throwing a lot of science questions into one. Usually you can't identify a single aspect of climate and study it in isolation. We want the flexibility for all the various conditions.

We talked about measurements over the long-term. UAVs are uniquely suited for repetitive missions over time.

Climate

1 CLIMATE M4b+1w3o4

SCIENCE GOAL

UNDERSTAND SENSITIVITY OF CLIMATE TO FORCINGS (SOLAR, CARBON CO_2, ALBEDO, CLOUDS, AEROSOLS AND H_2O) (See 3B)

BENEFIT TO SOCIETY

IMPROVE PREDICTION CAPABILITIES AND OUR UNDERSTANDING OF EMERGING DATA TO SUPPORT INTERNATIONAL AND DOMESTIC POLICY DECISIONS.

OBSERVATIONS REQUIRED

PROFILES OF STATE AND FORCINGS
RE: ATMOSPHERIC

WHY UAV?

HIGH RESOLUTION, IN SITU MEASUREMENTS OVER LARGE REGIONS AND LONG DURATION

LOW + SLOW

RISKY FLIGHT CONDITIONS

REPETITION CAPABILITY

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1 M4b+1w4o4

SCIENCE GOAL

DETERMINE SOURCES AND SINKS OF CARBON
CO_2 & METHANE

(See 2-1) and 4-1
SAME.

BENEFIT TO SOCIETY

DETERMINE WHICH REGIONS OF THE WORLD ARE SOURCES AND SINKS OF CARBON AS A DRIVER OF CLIMATE CHANGE

OBSERVATIONS REQUIRED

CO_2, METHANE, STATE VARIABLES AND DYNAMICAL TRACERS IN THE BOUNDARY LAYER AND FREE TROPOSPHERE.

WHY UAV?

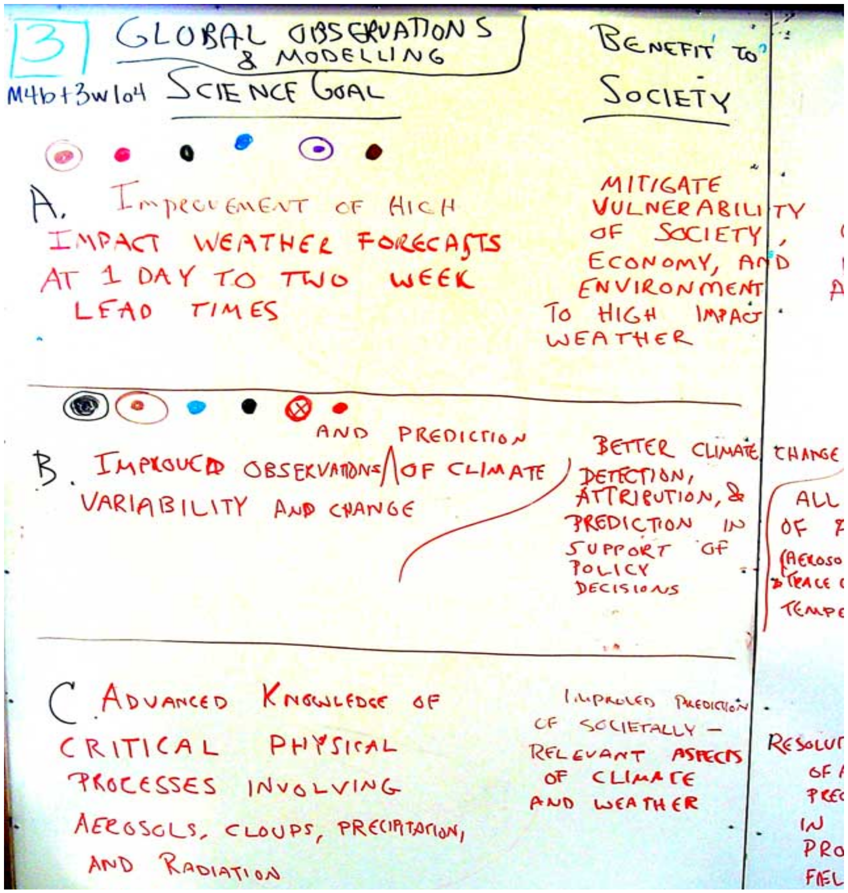
HIGH SENSITIVITY IN SITU MEASUREMENTS COUPLED WITH LONG RANGE

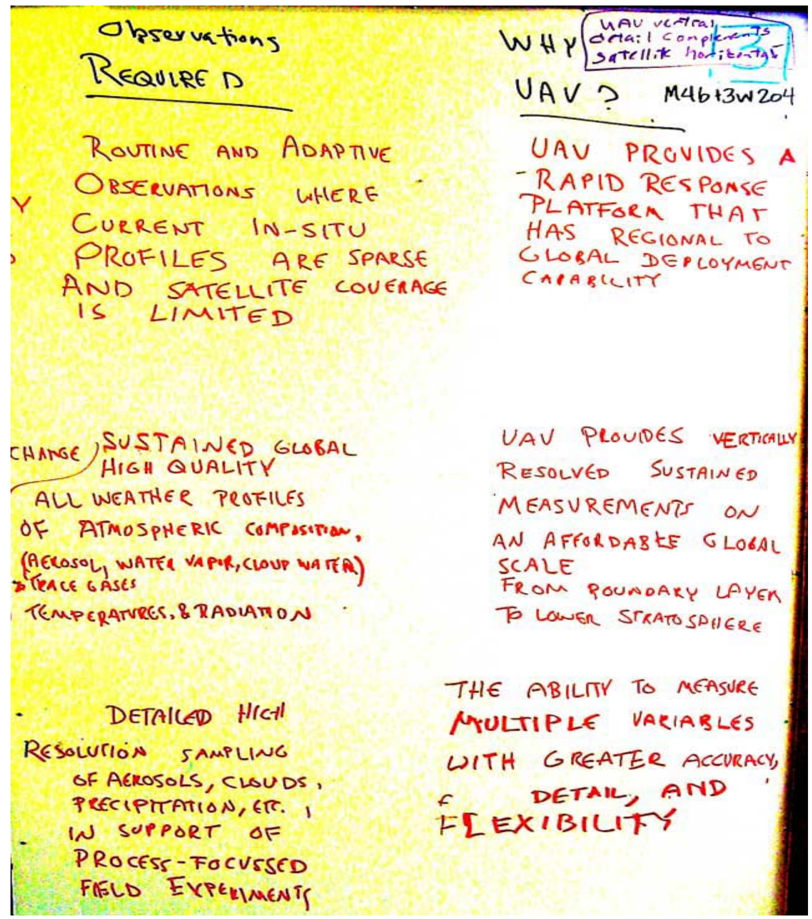
LOW + SLOW

RISKY FLIGHT CONDITIONS

Team 3 – Global Observations

Our first goal is improvement of high impact weather forecasts at one day to two week lead-times. Our second goal is the improved observation and prediction of climate variability and change. Our third goal is advanced knowledge of critical physical processes involving aerosols, clouds, precipitation and radiation.





Conversation

Why do we have to distill past this? Why can't we use all of these? It seems that it might be more powerful to use all of them?

You cannot determine CO2 fluxes from space. I see the UAV as a cost effective way. You should not take Battlestar Galactica as a UAV. Global coverage is less than one satellite.

There is the classical way to look at this is that we have a new science question we want to answer with UAVs. We could also ask some new science questions because of the UAV technology.

I don't see new science. We want to know how the planet is changing. None of our technology is answering these questions.

We're trying to create new questions when there aren't any, but we want to answer the questions that we haven't answered yet.

The societal need is to articulate the inadequacy.

The public's imagination is all about the satellite. Joe Farmer is right about observing things from the ground even though he doesn't know why.

Let's not put down the satellites but something in addition. We have something that is much more flexible.

The simplest way to say our purpose here is that we want to globalize in situ measurements.

We want to also cover the gaps in observations.

We're still missing the attribution question. We need to highlight it.

The need to document change over time is central to this. We haven't done that. It would also be good to have a portion of the program be flexible to invite investigators to come up with new ideas. Even with a distinguished group like this we won't come up with all the ideas. I would urge us to think about the possibility that satellite programs will bring in creative scientists who say there is something happening east of Greenland they want to look at and how we can say yes.

I see this as platforms being made available.

It will be a low cost package that you can fly at a convenient time into hazardous areas.

We calculated that you'd have access to anyplace in the global atmosphere within 48 hours. You could schedule flyovers in addition to the routines already in place.

You could think of a standard package, with basic instruments, along with bays for additional instruments that can be added as needed. If we think about this as infrastructure, the footprint of these instruments will become less important.

Next Steps

We're getting quickly into the action plans. We don't want to lose these elements. Can we boil this down to the major themes we want to go forward with?

Are there any missions that people are concerned with that we need to delete from the list?

The purpose of the voting was to be if we can converge to define an initiative. The other comment is that all of these ideas can fit into the one initiative. We will not lose any of these ideas but it will more powerful if we can focus on just a couple of programs to take forward for now.

We need to know what is going to be the headline. We need to have something on the flag. You can't have more than 3 things on there for people to pay attention to it.

Results

- Carbon fluxes
- Climate forcing
- Hazard/Events

Let's focus on the project planning, implementation, obstacles and next steps.

What happened to the vertical profiling? It's a tool towards the science questions.

Let's take the ones that have some sensitivity and see if we can collaborate with who we have here. It would test this marriage.

Final Report Out

High Impact Events: Prediction and Mitigation

We described high-impact events. They can either be environmental like air quality or could be weather, like periods above normal temperature which impacts energy management.

The obstacles with UAVs include the things on this list, such as the dropping of packages from aircraft. We have to work through a whole sequence such as the FAA and global air traffic control. We would have to be free of any danger to commercial aircraft. A number one priority is to develop a profiling system that is truly global.

We need to have total freedom to fly that craft.

You can argue why this is an issue when for decades we've been releasing plenty of balloon soundings with batteries in them that fall down and burst. Nobody cares. But these are dropsondes and there is nothing in the FAA or international regulatory definitions that include them. Right now the responsibility lies with the pilot.

The fact that we've done these dropsondes for all these years, doesn't that have some kind of proof that we can do this without serious problems?

There is a legal aspect and insurance policies that impacts us in regard to these things. We have to know how to respond to them.

Taking the right measurements over the oceans make a better forecast of events like flashfloods. The fires you had last year are a great example. If you knew about the warm pools in the western pacific, you would have the information to make better decisions to handle the emergency.

You needed to anticipate meteorological conditions for preparedness not only for FEMA but also for security. If you knew about the Santa Ana winds, you might set up a different security setup. We need to ask what the critical lead-times are to being to respond to the conditions.

We want to know through OSSEs (virtual) and actual demonstrations. WE can take actual target observations and experimental design studies. We need to have proof of concept to make the case for the validation of the UAV's use for high impact events.

I would add systems studies to operational concepts.

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We didn't say anything about the near-term next step.

High Impact Events

HIGH IMPACT EVENTS: PREDICTION & MITIGATION

1. HIGH IMPACT WX and environmental forecasts (1-2 wks), monitoring & mitigation

OBSTACLES

FAA - Terrestrial & Flight corridors

Proximity & Logistics for deployments

Int'l ATC

UAV ruggidized (all weather; cloud, precip, turbulence, thermal; continuous flts, reliability)

Remote deployment operations (runway, consummables, etc.)

Advancement of Technology (capabilities, streamline operation)

Standardization of Payloads & data management

'Public' acceptance of UAV operations

Maintainers of the system (who will 'own' & operate the 'system' - UAV ops)

Frequency management

Lack of advocacy group to raise awareness

OSSE - Observing System Simulation Experiment

OSE - Observing System Experiments

NEXT STEPS

2b [OSSE₁ : Potential impact on forecast skill / OSE₂ - Past experiments [illegible]] "As part of assimilation system" - "As part of full integrated observing system"

1. Proof of Concept: [illegible] UAV demos..

2a Develop operational concepts & SYSTEM STUDIES for UAV global observing system (Observing system potential designs)

3. Result: Impact on prediction, cost of system, feasibility

Carbon Fluxes

We looked at three different ways of sourcing trace gases. One is measurement through the atmospheric profile. The second method is boundary layer concentrations across the region of interest. The net change in gas concentration, you know what the sink is.

The eddy flux tends to be 100 meters beyond the canopy. You want to measure the trace gas fluctuation in the air movements.

Each of these methods has their advantages. You can get more integration with the second way and more precision with the first. We're talking about 800k transflucts. The profiling might be done every 800 km where the CO2 concentration winds are measured.

The obstacles are FAA and miniaturization of the sensors. The infrared gas sensors miniaturized would be saving some weight. This would help with the weight.

The hyperspectral device measure 256 bands and builds up a lot of data. Data management distribution will need to be done with the educational community as well as eventually the government agencies.

The cheaper it gets the more people can get involved such as universities.

We can do CO2 water vapor now but methane is very important and there is no good measure for it right now. A big trace gas of interest is N2O. Sources are areas that are nitrogen rich, such as tropics.

Duration is an obstacle especially over low altitude because of wind resistance.

The Predator might be useful for this. There are models that predict the flux and we could compare the measurements with the model results. What will take the largest lead-time is the eddy covariance.

This large scale profiling because it handles large regions, this might come out of the research centers, like NASA or DOE. The eddy flux you might expect to get into a university. For research one scientist if it were $300-500k a year, you could do this and get the data density you need.

To involve more people you could do the boundary layer measurements. That might be a $150k operation.

One of the ideas under discussion is that you can release a small model airplane from a high altitude and it could skim along at 100 meters taking measurements before it goes into the drink. There are other ways of getting these measurements.

We want to have the door open to all of these ideas. There are also tall tower approaches.

How do we decide whether North America is a source or a sink?

This gradient approach is the most appropriate for a large integration. There are 180 centers already in the U.S. If we could get them to use the UAVs we could cover the entire country for measurements.

The towers measure continuously, but the UAVs have temporal transfluxes.

I think with 4 eddy flux UAVs we would know confidently what the measurements are on the north slope of Alaska and we could measure it against our models. We'd have increasing scales.

OBSTACLES 1.2-2.1
NEXT STEPS
CARBON FLUXES

NACP
DOE NSF
40kg

Approaches
$300K/yr Eddy flux UAV 10-200m x 800km
Center/Lab/Research I
$150K/yr Boundary layer conc 100 m→1000m→1500m
multiple univ
$1M/yr Higher elevation - gradient 3 kg
7000 m 1-5 kg Predator

Obstacles
1) FAA
2) miniturization IRGA GPS-3D hyperspectral
3 Communication storage or down link
Near real time packets
Data mangmt & Distribution
→ Models ←
4) Cost
5) New sensors CH_4 N_2O
6) Duration @ LA.

Climate

We put a large emphasis on the basic state in profiling. As we address the science questions, we don't want this to get lost.

The obstacles were things that we were sure we were 100% we could achieve. Next steps are things we know how to do.

Funding is the biggest obstacle. Communication includes the three groups, our fellow scientists and the general public.

How do we sustain long-term, accurate measurements? I've never seen this done. There is not consistency or proper overlap when new instrumentation comes into play. For example, the calibration standards have changed over time and a lot of times our results get thrown out because we don't know how much of the effect comes about from the different measuring techniques.

Our next steps were similar issues but things we know how to do. We need to work on the international buy-in. Aircraft identification and development is what we need and where. Standardization of instrumentation is an enormous issue. We need to let the instrumentation community as soon as possible. We also need to have interaction with the modeling community.

This is an enormous group so we need to have as good communication as possible.

CLIMATE DETECTION, ATTRIBUTION AND PREDICTION.

* MONITORING OF PROFILES OF BAS STATE AND FORCINGS
  . CLOUDS, CO_2 + METHANE AEROSOLS, H_2O, DYNAMICS.

OBSTACLES

FUNDING

* COMMUNICATING THE NEEDS
  FUNDING + SCIENTISTS + PUBLIC

SUSTAINING MEASUREMENTS

BALANCING REGULAR MONITORING WITH FLEXIBILITY AND CAMPAIGNS

F.A.A. (CERTIFICATION) + INT'L

NEXT STEPS

COMMUNICATION (FUNDING, SCIENTIFIC, PUBLIC)

INTERNATIONAL BUY-IN

AIRCRAFT IDENTIFICATION AND DEVELOPMENT

INSTRUMENT DEVELOPMENT, CALIBRATION, STANDARDS + HOMOGENIZATION

INTERACTION WITH THE MODELING COMMUNITY.

IWGEO

We've added another column for the Suborbital Observing System.

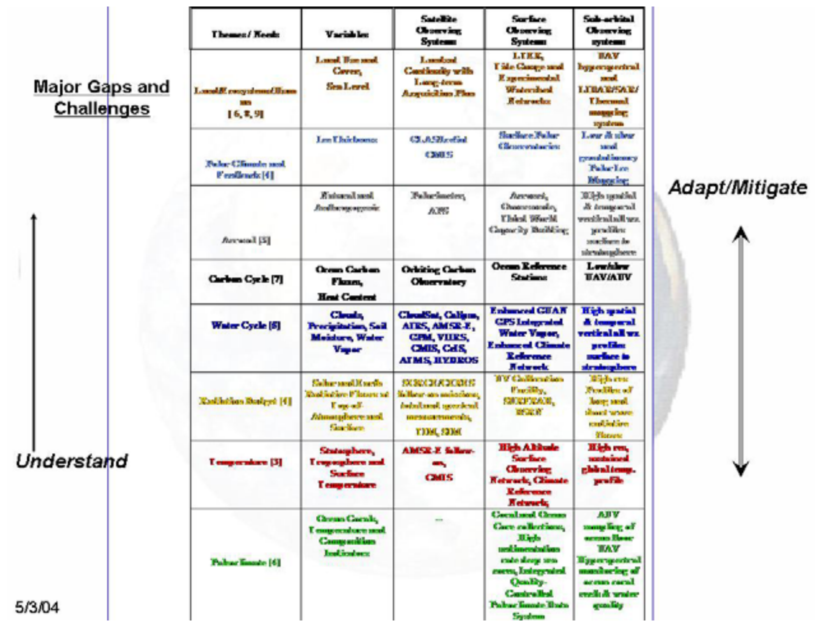
AUV are autonomous underwater vehicles. I think we can get a lot out of our thinking here for similar problems.

This chart goes into our Appendix 2 for climate. We also looked at Appendix 1 and I think we found only one place where airborne was mentioned and saw many other places where it needs to be mentioned.

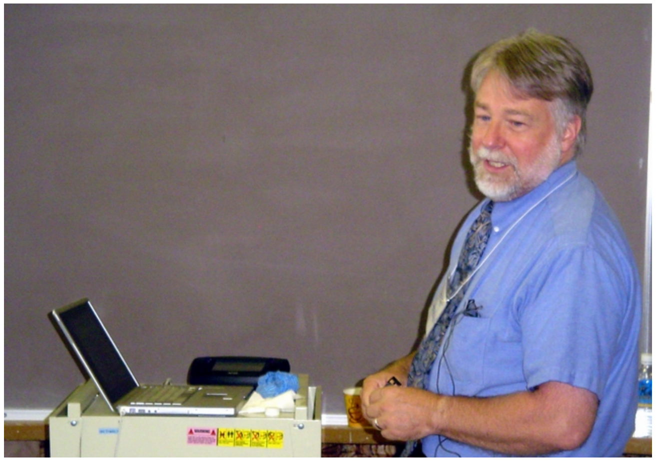
IPY isn't mentioned anywhere. This is definitely an early draft and hopefully people's comments can improve this. There was only one place where the UAV was specifically needed.

This plan should be out real soon.

Why did you restrict this to the ocean? There are many good places in lakes that can be used for measurement.



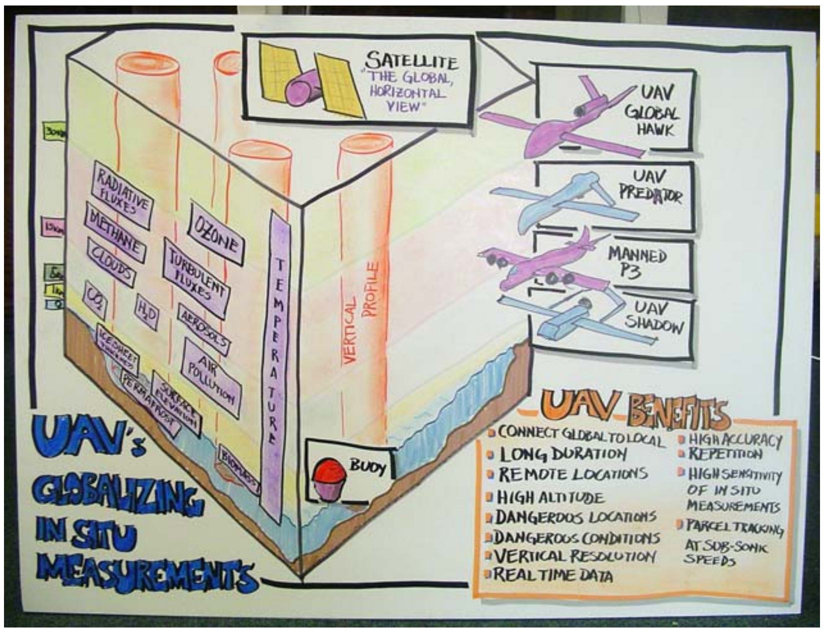
Themes / Needs	Variables	Satellite Observing Systems	Surface Observing Systems	Sub-orbital Observing systems
Land/Ecosystems/Human [6, 8, 9]	Land Use and Cover, Sea Level	Landsat Continuity with Long-term Acquisition Plan	LTER, Tide Gauge and Experimental Watershed Networks	UAV hyperspectral and LIDAR/SAR/ Thermal mapping system
Polar Climate and Feedbacks [4]	Ice Thickness	GLAS/ICESat, CMIS	Surface Polar Observatories	Low & slow and [illegible] Polar Ice Mapping
Aerosol [5]	Natural and Anthropogenic	Polarimeter, APS	Aerosol, [illegible], Third World Capacity Building	High spatial & temporal vertical aerosol profiles surface to stratosphere
Carbon Cycle [7]	Ocean Carbon Fluxes, Heat Content	Orbiting Carbon Observatory	Ocean Reference Stations	Low/slow UAV/AUV
Water Cycle [8]	Clouds, Precipitation, Soil Moisture, Water Vapor	CloudSat, Calipso, AIRS, AMSR-E, GPM, VIIRS, CMIS, CrIS, ATMS, HYDROS	Enhanced GUAN GPS Integrated Water Vapor, Enhanced Climate Reference Network	High spatial & temporal vertical all wx profiles surface to stratosphere
Radiation Budget [4]	Solar and Earth Radiative Fluxes at Top-of-Atmosphere and Surface	[illegible] follow-on missions, [illegible] measurements, TIM, SIM	UV Calibration Facility, SURFRAD, BSRN	High res Profiles of long and short wave radiative fluxes
Temperature [3]	Stratosphere, Troposphere and Surface Temperature	AMSR-E follow-on, CMIS	High Altitude Surface Observing Network, Climate Reference Network	High res, sustained global temp. profile
Paleoclimate [4]	Ocean Corals, Temperature and Composition Indicators	--	Coral and Ocean Core collections, High sedimentation rate deep sea cores, Integrated Quality-Controlled Paleoclimate Data System	AUV sampling of ocean floor UAV Hyperspectral monitoring of ocean coral reefs & water quality



Closing

Jay Smethurst

Here is a conceptualization and synthesis of the work you've done over the last couple of days. I'll be updating it and you'll receive the final version of it.



Langdon Morris

We appreciate being able to help you with you with this event. Do you have any comments for us about your experience?

It was very efficient. The 80/20 rule was very helpful.

How do you feel about the quality of what you've done? It's very superficial but that's appropriate at this stage.

The benefit was the cross education.

The multi-agency strategy and brining them all together in this format was very effective.

This was the right size for this kind of event.

Bill Ryan

I again would like to thank the committee who made this happen.

The CalSpace Institute feels we have a role to bring agencies and universities together. If you think we've fulfilled that role, please drop a note to me. I want to thank Innovation Labs for doing such a great job helping us with this event. If you need any group facilitation I highly recommend them.